petent to reduce the planetary rotation without directly affecting the satellite's orbital motion.

It is then shown to be probable that solar tidal friction was a more important cause of change when the planets were less condensed than it is at present. Thus we are not to accept the present rate of action of solar tidal friction as indicating that which has held true in all past time.

It is also shown that if a planetary mass generates a large satellite, the planetary rotation is reduced after the change more rapidly than before; nevertheless the genesis of such a satellite is preservative of the moment of momentum which is internal to the planetary sub-system. This conclusion is illustrated by the comparatively slow rotation of the earth, and by the large amount of angular momentum residing in the system of moon and earth.

An examination of the manner in which the difference of distances of the various planets from the sun will have affected the action of tidal friction leads to a cause for the observed distribution of satellites in the solar system.

According to the nebular hypothesis a planetary mass contracts, and rotates quicker as it contracts. The rapidity of the revolution causes its form to become unstable, or perhaps, as seems more probable, an equatorial belt gradually detaches itself; it is immaterial which of these really takes place. In either case the separation of that part of the mass which before the change had the greatest angular momentum permits the central portion to resume a planetary shape. The contraction and increase of rotation proceed continually until another portion is detached, and so on. There thus recur at intervals a series of epochs of instability or of abnormal change.

Now tidal friction must diminish the rate of increase of rotation due to contraction, and therefore if tidal friction and contraction are at work together the epochs of instability must recur more rarely than if contraction acted alone.

If the tidal retardation is sufficiently great, the increase of rotation due to contraction will be so far counteracted as never to permit an epoch of instability to occur.

Now the rate of solar tidal friction decreases rapidly as we recede from the sun, and therefore these considerations accord with what we observe in the solar system. For Mercury and Venus have no satellites, and there is a progressive increase in the number of satellites as we recede from the sun.

Whether this be the true cause of the observed distribution of satellites amongst the planets or not, it is remarkable that the same cause also affords an explanation of that difference between the earth with the moon and the other planets with their satellites, which has permitted tidal friction to be the principal agent of change with the former, but not with the latter.

In the case of the contracting terrestrial mass we may suppose that there was for a long time nearly a balance between the retardation due to solar tidal friction and the acceleration due to contraction, and that it was not until the planetary mass had contracted to nearly its present dimensions that an epoch of instability could occur.

If the contraction of the planetary mass be almost completed before the genesis of the satellite, tidal friction, due jointly to the satellite and the sun, will thereafter be the great cause of change in the system, and thus the hypothesis that it is the sole cause of change will give an approximately accurate explanation of the motion of the planet and satellite at any subsequent time. It is shown in the previous papers of this series that this condition is fulfilled with the earth and moon.

The paper ends with a short recapitulation of those facts in the solar system which are susceptible of explanation by the theory of the activity of tidal friction. This series of investigations affords no grounds for the rejection of the nebular hypothesis, but while it presents evidence in favour of the main outlines of that theory, it introduces modifications of considerable importance.

Tidal friction is a cause of change of which Laplace's theory took no account, and although the activity of that cause is to be regarded as mainly belonging to a later period than the events described in the nebular hypothesis, yet its influence has been of great, and in one instance of even paramount, importance in determining the present condition of the planets and their satellites.

G. H. D.

INDIGO

In July, 1878, an account was given in this journal of the synthesis of indigo-blue from phenylacetic acid, accomplished by Prof. Baeyer of Munich (NATURE, xviii. 251). The process there described did not permit of the successful production of indigo-blue on a manufacturing scale at reasonable cost. Since that time Prof. Baeyer has continued to work at the problem, and he has so far succeeded that he has now taken out a patent for the artificial manufacture and application of indigo-blue.

In a paper in the last number of the *Berliner Berichte* Baeyer gives an interesting *résumé* of the steps whereby progress has been slowly made, since 1865, in solving the problem of the synthesis of indigo.

Following up the work sketched in the article already referred to, Baeyer attempted to prepare *orthonitrophenyl acetic aldehyde*, expecting that this substance would yield indol, which may be regarded as the parent substance of the indigo group of compounds. But as the work proceeded Baeyer became more and more convinced that the hypothesis which had guided his earlier work was that which should still regulate his experiments. In 1869 he had written, "In order to prepare indol synthetically it is necessary—in accordance with the formula already given—to introduce a pair of carbon atoms and one nitrogen atom into benzene, and to link these together. The necessary conditions are found in *nitro-cinnamic acid*, if one supposes carbon dioxide and the oxygen of the nitro-group to be removed. And indeed it has been shown that nitro-cinnamic acid yields indol by fusion with potash." The steps in the preparation of indigo-blue, according to Baeyer's patent, are these:—

1. *Cinnamic acid* (or *phenyl acrylic acid*)—

$$C_6H_5 . C_2H_2 . CO_2H.$$

2. *Orthonitrocinnamic acid*—

$$C_6H_4\begin{cases} NO_2 \\ C_2H_2 . CO_2H. \end{cases}$$

3. *Orthonitrocinnamic acid dibromide*—

$$C_6H_4\begin{cases} NO_2 \\ C_2H_2Br_2 . CO_2H \end{cases};$$

prepared by acting on No. 2 with gaseous bromine and crystallising from benzene.

The dibromide in alcoholic solution is then treated with alcoholic potash, in the proportion of 1 : 2 molecules; and after dilution with water

4. *Orthonitromonobromcinnamic acid*—

$$C_6H_4\begin{cases} NO_2 \\ C_2HBr . CO_2H, \end{cases}$$

is precipitated. By again treating this acid with three molecules of alcoholic potash

5. *Orthonitrophenylpropiolic acid*—

$$C_6H_4\begin{cases} NO_2 \\ C_2 . CO_2H \end{cases}$$

is produced. When an aqueous solution of this acid is warmed with such feeble reducing agents as grape- or milk-sugar, in presence of caustic or carbonated alkali, indigo-blue separates in crystals. It is not however

necessary to prepare pure orthonitrophenylpropiolic acid; if orthonitrocinnamic acid (No. 2 above) be treated with bromine, then with alcoholic potash, and lastly with grape-sugar, without separating the various products indigo-blue is produced. Orthonitrocinnamic acid may be prepared, without difficulty, from oil of bitter almonds.

Artificial indigo may be directly printed on cloth by mixing orthonitrophenylpropiolic acid—or *orthonitrophenyloxyacrylic acid* described below—with soda and grape- or milk-sugar, and after proper thickening, soaking the cloth in the mixture, and heating: or the material may be simply soaked in orthonitrophenyloxyacrylic acid and heated.

Orthonitrophenyloxyacrylic acid is prepared by the action of alcoholic potash on an alcoholic solution of orthonitrophenylchlorolactic acid (itself prepared by the action of chlorine on orthonitrocinnamic acid), in accordance with the equation—

$$C_6H_4\begin{cases}NO_2\\C_2H_3OCl\,.\,CO_2H\end{cases} + 2KOH =$$
$$C_6H_4\begin{cases}NO_2\\C_2H_2O\,.\,CO_2K\end{cases} + KCl + H_2O.$$

By boiling an aqueous solution of orthonitrocinnamic acid dibromide (No. 3 above) with sodium carbonate, indigo blue separates out. M. M. P. M.

MICROSCOPIC STRUCTURE OF MALLEABLE METALS

THE following observations on the minute structure of metals, which have been hammered into thin leaves, are instructive. Notwithstanding the great opacity of metals, it is quite possible to procure, by chemical means, metallic leaves sufficiently thin to examine beneath the microscope by transmitted light. Silver leaf, for instance, when mounted upon a glass slip and immersed for a short time in a solution of potassium cyanide, perchloride of iron, or iron-alum, becomes reduced in thickness to any required extent. The structure of silver leaf may also be conveniently examined by converting it into a transparent salt by the action upon it of chlorine, iodine, or bromine. Similar suitable means may also be found for rendering more or less transparent most of the other metals which can be obtained in leaf.

An examination of such metallic sections will show two principal types of structure, one being essentially granular, and the other fibrous.

The granular metals, of which tin may be taken as an example, present the appearance of exceedingly minute grains, each one being perfectly isolated from its neighbours by still smaller interspaces. The cohesion of such leaves is very small.

The fibrous metals, on the other hand, such as silver and gold, have a very marked structure. Silver, especially, has the appearance of a mass of fine, elongated fibres, which are matted and interlaced in a manner which very much resembles hair. In gold this fibrous structure, although present, is far less marked. The influence of extreme pressure upon gold and silver seems to be, therefore, to develop a definite internal structure. Gold and silver in fact appear to behave in some respects like plastic bodies. When forced to spread out in the direction of least resistance their molecules do not move uniformly, but neighbouring molecules, having different velocities, glide over one another, causing a pronounced arrangement of particles in straight lines.

This development of a fibrous structure, by means of pressure, in a homogeneous substance like silver, is an interesting lesson in experimental geology, which may serve to illustrate the probable origin of the fibrous structure of the comparatively homogeneous limestones of the Pyrenees, Scotland, and the Tyrol.

J. VINCENT ELSDEN

ISLAND LIFE [1]

II.

IN the second half of his volume Mr. Wallace proceeds to apply to the elucidation of the history of the characteristic assemblages of plants and animals in islands, the principles laid down with so much explicitness in the first half. He points out that for the purposes of the naturalist a fundamental difference exists between islands that have once formed part of continents and those which have not. Continental islands are those which, by geological revolutions at more or less remote periods, have been severed from the continental masses in their neighbourhood. They are recognisably portions of the continental ridges of the earth's surface. This relation is usually made strikingly apparent by the chart of soundings between them and the nearest mainland (Fig. 2). Further, in geological structure they resemble parts of the continents, like which they contain both old and new formations, with or without volcanic accumulations. In some cases the evidence of recent severance from the adjacent continent is abundant. In others it is less distinct; for example, where the islands are separated from the nearest land by a depression of a thousand fathoms or more, and where their fauna, though abundant, is of a fragmentary nature, almost all the species being distinct, many of them forming distinct and peculiar genera or families, while many of the characteristic continental orders or families are entirely absent, and in their place come animals to which the nearest allies are to be found only in remote parts of the world. Oceanic islands, on the other hand, exhibit no geological connection with any continental area, but owe their birth either to upheaval of the ocean floor or to the piling up of lavas and tuffs round submarine vents of eruption. Their geological structure is of the simplest kind. As Mr. Darwin long ago showed, they consist of volcanic rocks or of coral reefs, or of volcanic and coralline formations combined. Ancient formations, so characteristic of continental islands, are wholly wanting. These islands lie far removed from a continent, and rise from water of profound depth. Their fauna is in curious keeping with this isolation, for it contains no indigenous land-mammals or amphibians, but abounds in birds and insects, and usually possesses some reptiles. These animals or their ancestors must have reached the islands by crossing the ocean.

Mr. Wallace first attacks the problems presented by the Oceanic Islands (Fig. 1). He describes the characters of the flora and fauna of the Azores, Bermuda, the Galapagos, St. Helena, and the Sandwich Islands, and endeavours in each case to show how the resemblances and differences between them and the plants and animals of the continents may be accounted for. The contrast offered by two groups of islands on either side of the American continent—the Bermudas and Galapagos—brings vividly before the mind the nature of the difficulties with which the author grapples, and the methods by which he seeks to solve them. In the case of the Bermuda group a series of coral islets having a total area of no more than fifty square miles rises from the very deepest depression in the Atlantic basin in 32° N. lat. at a distance of 700 miles from North Carolina. The chief elements in the fauna of these islands are birds and land-shells. Upwards of 180 species of birds have been observed, more than half of which belong to wading and swimming orders, while eighty-five are land-birds, of which twenty species are frequent visitors. Only ten species live as permanent residents on the island, and these are all common North American birds. No bird, and indeed no vertebrate animal, save a species of lizard, is peculiar to Bermuda. The feathered population of the islands is de-

[1] "Island Life; or, the Phenomena and Causes of Insular Faunas and Floras," &c. By Alfred Russel Wallace. (London: Macmillan and Co., 1880.) Continued from p. 359